DOCUMENT RESUME

ED 272 266 PS 015 392

AUTHOR Govier, Heather; Bake, Charles
TITLE Problems and Investigations in the Primary School.
INSTITUTION London Borough of Croydon Education Dept., Croydon (England). Davidson Centre.
PUB DATE Dec 84
NOTE 51p.; Filmed from best available copy. Illustrations and handwritten material may not reproduce well.
PUB TYPE Guides - Non-Classroom Use (055) -- Viewpoints (120) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Cognitive Ability; *Educational Innovation; *Educational Resources; Elementary Education; *Elementary School Curriculum; *Microcomputers; *Problem Solving; Program Descriptions; Program Implementation
IDENTIFIERS *Computer Uses in Education

ABSTRACT

One of a series, this booklet and related programs have been developed to help primary school teachers in England introduce problem solving and investigatory activities to their pupils. The theory of problem solving which underlies the views in this booklet is that of Professor Keith Jackson, director of the Bulmershe-Comino Problem Solving Project, who argues that people can learn to obtain better results by adopting a more methodical approach to life. Jackson differentiates ordinary, special, and problematic situations in life and identifies six sequential stages of problem solving methods and over 20 related strategies. Part 1 of this booklet identifies those stages and processes of problem solving and identifies problem solving strategies incorporated into 13 instructional computer programs for primary school students. Part 2 discusses children and problem solving, teachers and problem solving, using real problems in instruction, using investigations, and using microcomputers in problem solving and investigatory work by children. Guidelines for using the computer programs related to the booklet are offered, and other programs considered valuable for instructing junior age children are mentioned. Appendices describe the Bulmershe-Comino Problem Solving Project, report its findings, suggest guidelines for reviewing an exercise or lesson, list the stages and processes of problem solving, and report a junior school teacher's experience in introducing problem solving into the curriculum. (RH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED272266

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.
Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

PROBLEMS & INVESTIGATIONS

I.T. Unit, Davidson Centre, Davidson Road, CROYDON

01-654 3769

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Heather Govier
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

PS015392

INDEX

* Acknowledgements page 2

PART ONE: PROBLEMS, PUZZLES AND INVESTIGATIONS page 3

* Problems page 4

* Puzzles and Investigations page 11

PART TWO: PROBLEM SOLVING AND INVESTIGATIONS IN THE SCHOOL CURRICULUM page 12

* Children and problem solving page 12

* Teachers and problem solving page 14

* Using real problems page 16

* Using investigations page 16

* Using microcomputers page 17

* Using the programs in this pack page 20

* Other programs page 21

* Bibliography page 24

* Appendices

ACKNOWLEDGEMENTS

The materials in this Pack were developed at the Information Technology Unit of the Davidson Centre, Croydon for the MEP Project, *Problems and Investigations in the Primary School Using the Micro as a Resource*.

We would like to thank the following people for their support and valuable assistance in the development of the materials:

Members of the Steering Committee:

Mr G Alderson, Mr M Edey, Mr A Faulkner, Mr G Goldstein, Mr E Green, Mrs P Higgins, Professor K Jackson, Mr E H Leaton, Mr P McGee, Mrs A Milner, Mrs P Pulver, Mrs A Straker, Mr G Sullivan, Ms R Townsend, Mr P Wilkinson.

We are particularly indebted to Professor Keith Jackson who kindly allowed the use of extracts from his work and for his advice and constructive criticism of drafts of this booklet.

Members of the Working Party:

Ms L Ambrose, Mr B Booth, Mrs E Cox, Ms D Dorey, Miss J Healey, Mr H Hall, Mr R Harrison, Mr T Hayes, Mr G Hill, Mrs P Jennings, Mr P Matthews, Mr L Rosenfeld, Mr D Seston, Mr M Wallis.

Heather Govier
Charles Wake

For many of us the word "problem" may well have distasteful resonances recalling those long, involved, wordy conundrums that invoked a frisson of despair during our own schooldays.

The following example should serve as a reminder:

"*A dishonest tradesman marks his goods at an advance of 5 per cent on the cost price, but uses a fraudulent balance, whose beam is horizontal when the weight in one scale is one fifteenth more than the weight in the other. What is his actual gain per cent?*" (*Arithmetic*, D. A. Young, the Dunnington Press, 1928)

Yet not all problems are abstract mathematical teasers. In our everyday lives we are constantly beset by problems: perhaps seeking an alternative route to work when the usual one is blocked or finding a way to cope with a particularly large and overgrown garden.

Thus problem solving is not something that takes place only in schools, nor can it simply be allocated a slot in the curriculum, studied, then set aside. Problem solving techniques can be learnt and should be applied whenever circumstances demand, both within the curriculum and in approaching difficult situations in day to day life. These booklets and programs have been developed to help teachers to introduce problem solving and investigatory activities to their pupils. While the microcomputer serves as a focus for the work, much of value is derived from activies which take place away from the keyboard, and suggestions for such activities form a vital part of the package. Moreover the ideas presented in this booklet, and in the documentation which accompanies the computer programs, can be seen as starting points for further explorations in problem solving and investigations rather than as ends in themselves.

The theory of problem solving which informs the views in this booklet is that forwarded by Professor Keith Jackson, Director of the Bulmershe-Comino Problem Solving Project at Bulmershe College Reading. He has provided invaluable support and advice in the development of these MEI Project materials. Details of his work will be found in the bibliography.

Professor Jackson argues that people can learn to obtain better results by adopting a more methodical approach to life. Occasions when varying degrees of method are required can be divided into three types: ordinary, special, and problems. Different techniques can be applied to each in order to achieve desired ends. Examples of the three different kinds of situations are shown in the following table:

GETTING RESULTS

1.ORDINARY SITUATIONS	2.SPECIAL SITUATIONS	3.PROBLEMS
In ordinary situations we manage to get things done and overcome minor obstacles though our approach is seldom methodical. Thus we live our lives, buy shopping, get to work, tidy the garden and so on.	On special occasions where the achievement of a particular end is important to us then it pays to adopt a more methodical approach. Thus we may think carefully about how we are going to approach decorating a room or how we are going to present arguments in a discussion or interview.	Sometimes when we are successfully getting results we come across an obstacle that puts this happy state of affairs into jeopardy - this is a problem and must be dealt with if we are to continue getting results.

PROBLEMS

Ok, what is a problem?

All problems possess two features: an objective and an obstacle:

"Problem solving occurs when a person trying to achieve a particular goal or objective is thwarted (blocked, frustrated, prevented) from attaining this goal directly. In these circumstances the person must work out (devise, discover) a method for attaining the goal.

The block is itself the problem, and the method, when worked out, is the solution. The working out or 'discovery' of such a method is the art of problem-solving." (Open University Course D303 *Cognitive Psychology* Part 2 page 8)

The following section summarizes Jackson's views on problem solving which are elaborated in his paper in Appendix A.

We need a systematic problem-solving method at our disposal to cope with problems. Jackson identifies six sequential stages:

1. FORMULATION: A problem must be detected, often through a feeling of unease or dissatisfaction, then stated clearly with both the objective and obstacle defined;

2. INTERPRETATION: We need to identify and analyse the essential elements of the problem to find out as much as possible and so make sure that we understand it;

3. CONSTRUCTING COURSES OF ACTION: Before starting we should make a plan of what we intend to do to try to solve the problem - there may be several possible courses of action open;

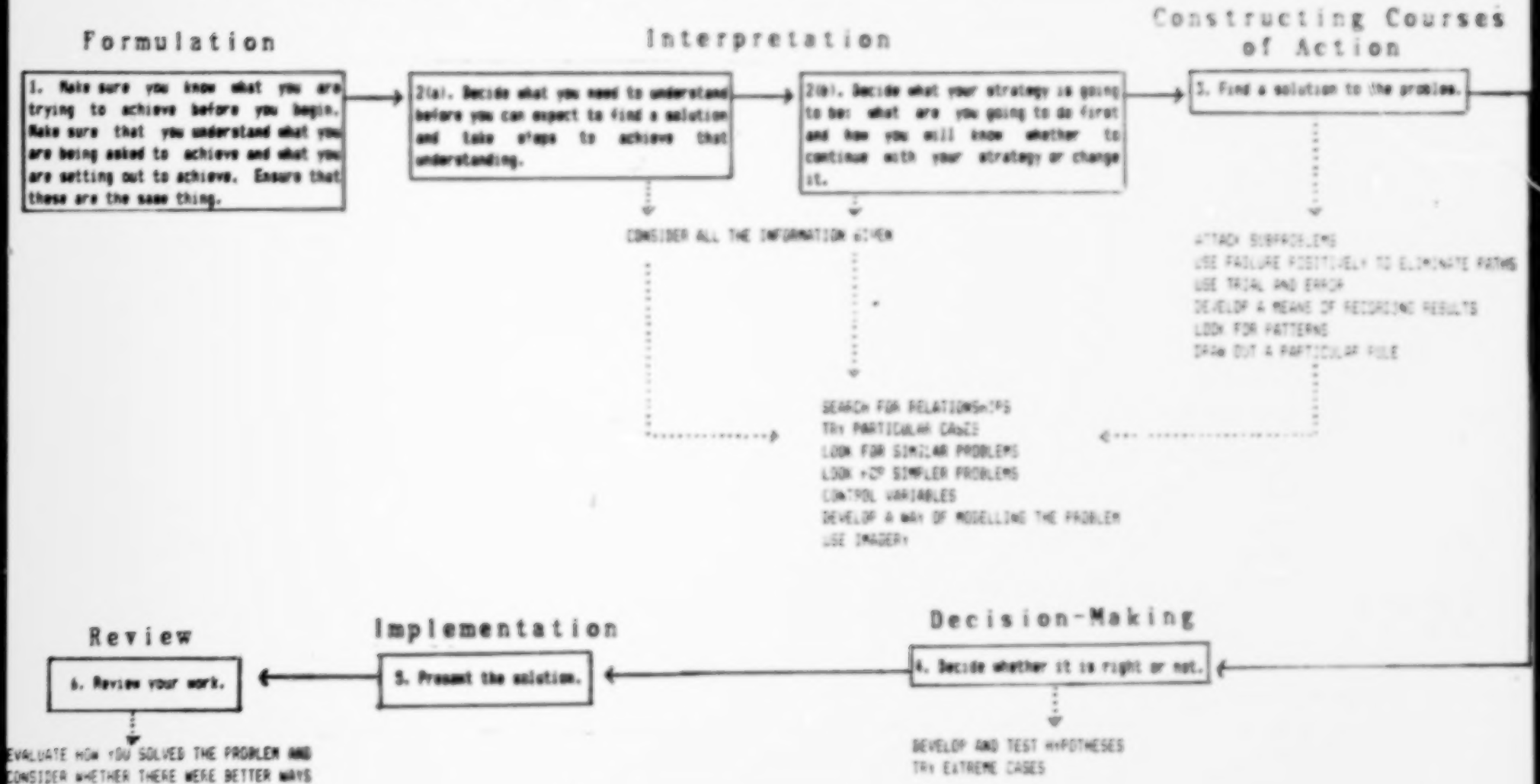
4. DECISION-MAKING: Here we choose a particular course of action and commit ourselves to it.

5. IMPLEMENTATION: We put our plan into action.

6. REVIEW: For maximum benefit to be derived it is essential to review the whole process to see what lessons can be learnt for next time. The review stage is vitally important and is something that teachers should emphasise when undertaking problem solving with children. The best way to review a lesson is by asking questions of the children rather than exposition by the teacher of what happened. A list of fourteen questions to ask can be found in Appendix B.

During problem solving a variety of skills and techniques are used, some throughout the process and others just at one or two particular stages. These are listed below and their inter-relationship with the six stages summarized by the diagram on the following page.

THE STAGES AND PROCESSES OF PROBLEM SOLVING


Formulation
1. Make sure you know what you are trying to achieve before you begin. Make sure that you understand what you are being asked to achieve and what you are setting out to achieve. Ensure that these are the same thing.
Interpretation
2(a). Decide what you need to understand before you can expect to find a solution and take steps to achieve that understanding.
2(b). Decide what your strategy is going to be: what are you going to do first and how you will know whether to continue with your strategy or change it.
CONSIDER ALL THE INFORMATION GIVEN
SEARCH FOR RELATIONSHIPS
TRY PARTICULAR CASES
LOOK FOR SIMILAR PROBLEMS
LOOK FOR SIMPLER PROBLEMS
CONTROL VARIABLES
DEVELOP A WAY OF MODELLING THE PROBLEM
USE IMAGERY
Constructing Courses of Action
3. Find a solution to the problem.
ATTACK SUBPROBLEMS
USE FAILURE POSITIVELY TO ELIMINATE PATHS
USE TRIAL AND ERROR
DEVELOP A MEANS OF RECORDING RESULTS
LOOK FOR PATTERNS
DRAW OUT A PARTICULAR RULE
Decision-Making
4. Decide whether it is right or not.
DEVELOP AND TEST HYPOTHESES
TRY EXTREME CASES
Implementation
5. Present the solution.
Review
6. Review your work.
EVALUATE HOW YOU SOLVED THE PROBLEM AND CONSIDER WHETHER THERE WERE BETTER WAYS

PROCESSES THAT PREVAIL THROUGHOUT ALL OF THE STAGES

- BE SYSTEMATIC
- TALK THROUGH THE PROBLEM IN YOUR HEAD
- COLLABORATE WITH OTHERS
- COMMUNICATE THOUGHTS TO OTHERS

BE SYSTEMATIC
A systematic strategy applied to solving problems will usually prove more successful than a haphazard approach.

TALK THROUGH THE PROBLEM IN YOUR HEAD
Thinking about a problem, asking questions about it and making explicit what is known and what is to be found are techniques that often serve to clarify a previously obscure problem.

COLLABORATE WITH OTHERS
Members of groups can often spark ideas off one another and so make progress towards a solution.

COMMUNICATE THOUGHTS TO OTHERS
This is a useful technique for clarifying and ordering ideas and is an essential component of solving the problems presented in each of the programs in this suite.

CONSIDER ALL THE INFORMATION GIVEN
The solution to a problem will invariably depend upon the solver considering all the information given in the problem, whether stated or implied.

SEARCH FOR RELATIONSHIPS
The identification of links between seemingly disconnected items of data can make sense of a problem and provide an insight into a possible method of solution.

TRY PARTICULAR CASES
Investigating "what happens if" is usually necessary in order to get a sense of a problem and begin to make progress towards its solution (e.g. substituting values for letters in algebraic formulae).

LOOK FOR SIMILAR PROBLEMS
Many new problems have similarities with those which have been solved previously and may share common features in their

solutions. The identification of such similarities is a valuable skill.

LOOK FOR SIMPLER PROBLEMS
An insight into a way of attacking a complex problem can often be gained by finding a simpler problem for which a solution can be found.

CONTROL VARIABLES
Where an outcome is dependent on the interplay of several variables then it is necessary to isolate one at a time so as to assess its particular effect.

DEVELOP A WAY OF MODELLING THE PROBLEM
The use of diagrams, pictures or apparatus to make a representation of the problem can make it easier to apprehend.

USE IMAGERY
Children generally find it helpful to develop their own imagery and terminology to help them conceptualize a problem.

ATTACK SUBPROBLEMS
It is helpful to break an intricate problem down into manageable chunks and attack each separately.

USE FAILURE POSITIVELY TO ELIMINATE PATHS
If particular avenues of investigation fail to lead to a solution then they can be eliminated from consideration so narrowing the field.

USE TRIAL AND ERROR
Children should be prepared to make mistakes and to view these as learning experiences rather than failures. Errors are both unavoidable and valuable and a debugging process is essential in refining solutions to problems.

DEVELOP A MEANS OF RECORDING RESULTS
This is necessary in order to be able to

chart progress and identify possible routes to a solution.

LOOK FOR PATTERNS
Underlying patterns have to be identified if a generalization is to be made.

DRAW OUT A PARTICULAR RULE
It may be possible to state a rule which governs all instances of a problem.

DEVELOP AND TEST HYPOTHESES
The reasoning underlying a possible solution to a problem should be given then the hypothesis tested to see if it holds under all conditions.

TRY EXTREME CASES
One way of testing an hypothesis is to try extreme cases. This will help to highlight underlying patterns of results and it may show that the hypothesis does not hold after all.

EVALUATE HOW YOU SOLVED THE PROBLEM AND CONSIDER WHETHER THERE WERE BETTER WAYS
The review stage should not be neglected as it offers the opportunity to reflect on the methods used to solve the problem and consider whether a more efficient strategy could have been employed.

IT IS TOWARDS THE INTRODUCTION AND USE OF THESE STRATEGIES THAT THE MEP PROGRAMS ARE PRINCIPALLY DIRECTED. The links between the programs and these strategies are given on the next page and expanded in Appendix C.

Although the stages and skills have been presented in the form of sequential skills, problem solving is rarely a linear process. It may be necessary to repeat steps in a cyclical manner until flashes of insight (the "Aha!" reaction) provide the way forward.

These insights do not occur spontaneously but happen when some effort is made to try to solve the problem. They may result from the association of ideas that are not usually linked. We tend to think of ideas in "frames" or "mental models which limit our thoughts to relevant topics. Insights arise from introducing concepts from another frame or considering two frames together.

Applicable to the program: ✓

Main problem solving objective: ✓✓

	BE SYSTEMATIC	TALK THROUGH THE PROBLEM IN YOUR HEAD	COLLABORATE WITH OTHERS	COMMUNICATE THOUGHTS TO OTHERS	CONSIDER ALL THE INFORMATION GIVEN	SEARCH FOR RELATIONSHIPS	TRY PARTICULAR CASES	LOOK FOR SIMILAR PROBLEMS	LOOK FOR SIMPLER PROBLEMS	CONTROL VARIABLES	DEVELOP A WAY OF MODELLING THE PROBLEM	USE IMAGERY	ATTACK SUBPROBLEMS	USE FAILURE POSITIVELY TO ELIMINATE PATH	USE TRIAL AND ERROR	DEVELOP A MEANS OF RECORDING RESULTS	LOOK FOR PATTERNS	DRAW OUT A PARTICULAR RULE	DEVELOP AND TEST HYPOTHESES	TRY EXTREME CASES	EVALUATE HOW YOU SOLVED THE PROBLEM AND CONSIDER WHETHER THERE WERE BETTER WAYS	
BEES	✓	✓	✓	✓	✓✓	✓✓	✓✓			✓✓			✓	✓✓	✓✓	✓	✓	✓✓	✓	✓✓	✓	
CHICKS	✓	✓	✓	✓	✓✓	✓✓	✓✓			✓✓			✓	✓✓	✓✓	✓	✓	✓✓	✓	✓✓	✓	
COLONY	✓	✓	✓	✓	✓	✓	✓✓		✓✓		✓	✓✓		✓	✓	✓	✓	✓	✓			
MAP TRAY	✓	✓	✓	✓	✓✓	✓✓	✓✓	✓					✓	✓	✓	✓	✓		✓			
RAYBOX	✓	✓	✓	✓	✓✓	✓✓	✓✓		✓			✓✓		✓✓	✓✓	✓		✓	✓	✓	✓	
SECRET	✓	✓	✓	✓	✓✓			✓✓					✓		✓		✓		✓		✓	
SHUNT	✓	✓	✓	✓	✓			✓✓			✓✓		✓✓		✓	✓	✓				✓	
SPIRO+	✓	✓	✓	✓	✓	✓	✓✓		✓✓	✓✓	✓		✓	✓	✓	✓	✓✓	✓	✓✓		✓	
STRATEGY	✓	✓	✓	✓	✓		✓✓	✓						✓	✓	✓	✓	✓✓			✓	
SUPER RAY	✓	✓	✓	✓	✓✓	✓✓	✓✓		✓	✓✓		✓✓		✓✓	✓✓	✓		✓	✓✓	✓✓	✓	
TRAY	✓	✓	✓✓	✓	✓✓		✓						✓	✓✓	✓✓		✓				✓	
TRIANGLES	✓	✓	✓	✓	✓	✓	✓✓								✓	✓					✓	

PUZZLES AND INVESTIGATIONS

While the terms problem, puzzle and investigation are often loosely used as synonyms it is helpful to make a distinction between the three types of activity.

A problem has already been defined as an obstacle encountered in the process of trying to achieve a particular goal. Problem solving consists of devising a method to overcome the obstacle.

Problems may be encountered in the process of solving puzzles or pursuing investigations, although simple puzzles and investigations may be problem free.

A puzzle has a unique solution but problems need not have. Thus the Rubik cube is a puzzle as are the many questions in mathematics books frequently given the misnoma "problems". Deciding how to slim when one is overweight however is a problem which could have various solutions depending on one's lifestyle and willpower.

Investigations may be carried out as part of the problem solving process when more information is required before a decision can be made. This may happen during the *Interpretation* stage when the problem is being stated and clarified or later during *Constructing courses of action* when various paths may need to be explored in order to establish which is the most satisfactory. Alternatively investigations may be carried out for their intrinsic interest quite apart from any 'use' they may be in the solution of problems. Investigation is substantially different from problem solving in that there is no obstacle and the objective may be simply to satisfy curiosity. Most investigations are open-ended having no clear-cut conclusion whereas problems have a definite climax or finale when a solution is found.

It is possible for both puzzles and investigations to turn into problems if progress is halted by some difficulty.

Problems, puzzles and investigations can be found in all parts of the curriculum and explored through use of a common set of skills and techniques. Special activities such as brainstorming and subject specific approaches such as mathematical conjecture or scentific method can all be viewed within Jackson's theoretical and methodological framework for getting results.

PART TWO: PROBLEM SOLVING AND INVESTIGATIONS IN THE SCHOOL CURRICULUM

"Human beings need to be able to get results and solve problems in order to survive and to live satisfying lives. Although the idea of getting results as a general theme of education is relatively uncommon, the idea of solving problems is discussed frequently and sometimes adopted as an educational objective. However, not much is done in schools to teach pupils either how to get results or how to solve problems in the general sense." (K. F. Jackson, from his Introduction to *The Bulmershe-Comino Problem-Solving Project* paper in Appendix A)

Virtually all official reports on primary education such as those produced by HMI and the Schools Council point to four major deficiencies in primary school practice. These criticisms, which have been repeated for well over fifty years, are as follows:

a) Brighter pupils are frequently given work which is not sufficiently demanding;

b) Children are offered few opportunities for problem solving activities and few opportunities to apply basic skills in novel contexts;

c) Pupils are rarely required to use higher order thinking skills such as inference, deduction, analysis or evaluation;

d) Except on the games field there is little true group work where pupils may develop the social skills of cooperation and communication.

When combined with the need already stated for problem solving skills in everyday situations this provides a compelling rationale for the inclusion of work on problems and investigations in the primary curriculum.

CHILDREN AND PROBLEM SOLVING

The recognition that most children are unable to solve problems and apply knowledge and skills in unfamiliar situations can be traced back in reports on education over many years.

For example, it might be supposed that the statement that children are "unable to solve very simple problems" was of fairly recent origin - part of the educational debate of the 1970s perhaps? But no, this was a comment made some ninety years ago in 1895!

It is not a lack of mental capacity which accounts for this deficiency but the failure of schools to utilise children's talents to the full. The ability of children to reason and resolve problems was noted in 1912: "intelligence is an equipment incomparably more valuable than facility in calculation" and in the Hadow Report of 1931: "the power of reasoning in children between the ages of 7 and 11 appears to be more highly developed than is generally supposed."

More recently, the findings of the APU in the late seventies have highlighted the fact that children's performance in mathematics declines when they are presented with unfamiliar contexts and that at the age of 11 it is difficult for pupils to extract essential details from more complex situations.

The *Cockcroft Report* (1982) states that "The ability to solve problems is at the heart of mathematics. Mathematics is only 'useful' to the extent to which it can be applied to a particular situation and it is the ability to apply mathematics to a variety of situations to which we give the name 'problem solving'" (paragraph 249). It further points out that "The idea of investigation is fundamental both to the study of mathematics itself and also to an understanding of the ways in which mathematics can be used to extend knowledge and to solve problems in very many fields" (paragraph 250).

Paragraph 323 states that general strategies directed towards developing skill in problem solving and investigations could start during the primary years. In this context the children should be given the opportunity to see that graphical or diagrammatic representations of problems can often lead to the discovery of patterns and that experiments to test conjectures might need to be set up. They will require persistence in exploring a problem and will have to learn how to record the possibilities that have already been tried. Underlying this is the necessary ability to work with others and communicate progress that has been made by means of words, diagrams and symbols.

Recently, Dr Leonie Burton (1984) has pointed to the educational value of problems and investigations:

1. They enthuse and excite pupils.

2. They provide opportunities for creativity.

3. They can be tackled at various levels of sophistication so everyone can enjoy and achieve something.

4. They build confidence and independence.

5. They develop collaborative learning.

6. They enable pupils to recognise and apply what they have already stored.

7. They shift the focus of attention from what is learned, to how that learning is used.

8. They give meaning and value to the study of mathematics.

(Leonie Burton, *Thinking Things Through*, page 18)

"The overwhelming importance of problem solving, therefore, is in the opportunity it provides for teachers and pupils to enter into a spirit of enquiry and through that spirit to establish different styles of teaching and learning." (Leonie Burton op.cit. p10)

TEACHERS AND PROBLEM SOLVING

Despite the repeated acknowledgement that schools seldom provide children with opportunities to use the abilities they possess to solve problems, classroom practice generally fails to meet the challenge. If teachers are to attempt to introduce problem solving and investigations into the classroom then several things need to be borne in mind:

- Problems are not simply 'sums with words';
- The teacher needs to have an understanding of a structure which can be applied to the analysis and solving of problems;
- Problems need to be recognized as such and not simply as situations that cannot be immediately resolved;
- The teacher must be prepared to guide the children's thinking through carefully planned interventions and avoid imposing her methods on the children by telling them what to do. This may even require the teacher to allow the children to explore blind alleys even though she can see they will lead nowhere;
- The teacher needs to be on the look out for situations which can be exploited for their investigational or problem solving potential in all aspects of the curriculum;
- Children should be encouraged to develop ways of recording their progress. Paper and pencil (or perhaps something like mathematical

> apparatus) allows us to extend our short-term memory. Writing aids clear thinking about problems, helps us to see patterns and decide what type of problem we are dealing with. But the usefulness of this is lessened if we lack suitable notation for recording chunks of information. "The application or discovery of a suitable notation is often a crucial step in solving a problem." (Grogono and Nelson, *Problem Solving and Computer Programming* page 7)

One feature of problem solving activities that teachers may find threatening is the change in styles of teaching and learning that may be required. Problem-solving is best undertaken in groups where individual members are trying to argue their points with other members and with the teacher. This requires the teacher to relinquish a lot of the control usually exercised in the classroom and to put the burden of control (in the form of self-control) onto the children. Pupils must be given more responsibility for their own learning. It also necessitates the teacher's adopting a different role. Instead of being the provider of answers the teacher must be the *resource* for the children as they find their own answers. In practical terms this means supplying everything necessary (not only books, paper etc. but rooms or areas in which discussions can take place) and stimulating clarification and further thought by asking questions of the children. This questioning is not quite as easy as it sounds and it is usually necessary for a teacher to think ahead about the sorts of open-ended questions that she will ask and structuring the lesson. A checklist, devised by Professor Jackson, which may be useful in planning lessons is given below. Appendix D (*Problem-Solving News*, Issue No. 12 July 1984) contains a case study of the sort of work which can be achieved with junior children.

Make sure that these steps are taken:

1. Explain to the pupils what they are supposed to be trying to learn;

2. Establish that each pupil has a clear idea how she will approach the task;

3. At intervals throughout the task check whether or not the original plan is being followed;

4. If problems arise the pupils should stop and either tackle the problems themselves or ask for help. If they ask for help the teacher should insist that the pupils define the problem and proceed stage by stage, reporting back to the teacher either at each stage or at the end of the solution process;

5. Review fully with the pupils afterwards (as per Appendix B) so

that they gain as much as possible from the experience and pass on what they have learnt to others.

USING REAL PROBLEMS

One way of incorporating problem solving into the curriculum is to make use of the many opportunities that present themselves in the form of real problems: that is problems where their solution will have a real and practical effect on the children's lives (e.g. the alteration of the layout of a classroom, a choice in the menu for school dinners, the provision of clubs and societies).

"For most people a real problem-in everyday life consists of a practical, immediate impediment to what is considered to be safe living (e.g. the condition of the car, the route to work) or satisfying living (e.g. how can the family reconcile their various demands on their living space?). Usually, a real problem seems to be ill-defined, complex (rather than superficial or simple) and many-faceted (rather than just one aspect)." (Open University Course PME235 *Mathematics Across the Curriculum*, Unit 5 page 10)

However to approach the teaching of problem solving techniques from real problems is not a particularly straightforward task in the primary classroom. A problem would have to be found that was of vital importance to all the children in the class and, for any educational benefit to be gained, its resolution would have to be undertaken by pupils and not by the teacher. Manifold difficulties might arise. The problem might well prove to be too large for the children to cope with and lack the structure necessary to illustrate the essential nature of problem solving technique. Furthermore, a clear, verifiable answer might not be forthcoming. This could be very disheartening to the less committed.

For teachers who wish to pursue work on real problems the above-mentioned Open University course *Mathematics Across the Curriculum* is an ideal introduction to the ways in which real-life problems can be used for classwork by pupils of all ages.

USING INVESTIGATIONS

The use of investigational activities in mathematics is hardly new. In almost every school in the country each September there are children discovering what number patterns they can find on 10x10 number grids. Similarly investigations are often made into the patterns of square and triangle numbers and of the Fibonacci sequence. Investigations can also be undertaken in other subject areas, for example:

Science:	what affects the swing of a pendulum? how can various leaves be classified? how is heart rate affected by activity?
P.E.:	how many different ways of balancing can be found? will changes in the rules of a game make it more fun?
Language:	how many synonyms can be found for over-used words? which styles of calligraphy are best for large notices?
Geography:	why have major cities sprung up in particular locations? why do certain products grow only in given climates?
Art:	how does texture vary when paints are mixed in varying ways? which media are most efective when making junk models?

Teachers who have done this type of work with pupils will be well aware that children enjoy undertaking such work and can attempt it whatever their ability level. The more able children should be capable of constructing complex hypotheses and perhaps generating their own investigations. Thus children engaged in making models might explore the effectiveness of types of glue with different materials.

USING MICROCOMPUTERS

One (quite justifiable) excuse for past failure to include much problem solving work in the curriculum is the difficulty that teachers have in thinking up problems for their pupils to solve. Work with LOGO such as that described by Papert (*Mindstorms*, The Harvester Press, 1980) has shown that children instructing a computer generate an endless stream of problems which they are highly motivated to solve. This problem posing activity is not specific to LOGO but arises whenever pupils are working with open-ended software which allows conjecture and encourages exploration.

The ability of the computer to generate random numbers allows infinite numbers of examples to be produced. Microcomputers can be used to set up experiments in which processes can be repeated any number of times, each, if required, with a slight variation. This enables children to test hypotheses over a large number of instances and facilitates the recognition of underlying patterns in the results obtained. For example if the children are investigating the relationship between the number of diagonals and the number of sides of plane shapes then a simple computer program can be used to generate instances of multi-sided shapes and accurately draw and count the number of diagonals. If doing this by

hand children might easily miss out at least one diagonal either when drawing or counting and thus not have the correct information on which to base their hypotheses. The micro thus reduces the physical drudgery of the task allowing pupils to concentrate on the creative aspects.

Simulations of scientific experiments can be presented allowing hypothesis formulation and testing in an environment free of the dangers, difficulties and expense of real experimentation. Throughout all of this the speed of presentation of examples and the degree of difficulty can be easily controlled by pupils or teacher.

In the same way that pocket calculators can be used to focus on the underlying mathematics of a problem rather than worrying about the computation so microcomputers can serve as *useful tools* when children are trying to investigate topics and solve problems. The *Microprimer Study Text* points to two features of micros that are particularly useful - wordprocessing and data handling:

"In the planning stage, for instance, the development of drafts using the micro as a word processor allows users to develop their initial thoughts easily and flexibly, by allowing them to juggle their perceptions around, switching words, sentences and paragraphs at the touch of a button until they feel that they have caught their thoughts. Word processing frees them from the wordsmithing needed to redraft the perfect rewrite which usually destroys creative thinking.

The process of marshalling information is greatly assisted by the use of the micro for sifting and sorting through large quantities of raw data, allowing the user to concentrate on the selection and combination of relevant facts" (Microprimer *Study Text* page 107).

As a stimulus for group activity the microcomputer outshines all rivals. The monitor provides a central focus for all eyes while the single keyboard requires that a consensus be reached before any input is made. Groups working together around a computer indulge in a depth of discussion rarely encountered in primary classrooms. Such discussion is an essential component of collaborative problem solving work.

Finally when problems or investigations involve the provision of feedback by an opponent (as does the boardgame *Mastermind*) the computer, unlike a human adversary, can be depended upon to provide reliable information. A major difficulty in playing *Mastermind* with children is that the solver is frequently given inaccurate information, making the task virtually impossible.

In summary, the microcomputer can make the following contributions to

problem solving and investigatory work:

a) it can sustain interest and maintain attention;

b) it can provide simulations allowing experimentation which is not dangerous, expensive or difficult;

c) infinite numbers of examples can be generated;

d) it allows conjecture and encourages exploration;

e) it facilitiates group interaction;

f) speed of presentation and degree of difficulty can be easily controlled;

g) reliable feedback can be provided.

USING THE PROGRAMS IN THIS PACK

Aims

The general aims of the programs should be to develop:

- *a confident and methodical approach to solving problems;*
- *persistence;*
- *logical reasoning;*
- *the use of language to explain this reasoning;*
- *a willingness to listen to other people's points of view;*
- *a group acceptance of an agreed action;*
- *the ability to make informed choices between possible courses of action;*
- *the ability to record information succintly;*
- *a recognition by teachers of the importance of problem solving activities and an understanding of the ways in which they can help pupils to overcome difficulties.*

The computer programs in this pack present children with challenges that are designed to stimulate investigations and encourage the use of systematic problem solving strategies. The sixteen programs that constitute the whole suite concentrate on different aspects of these strategies.

The aim has been to develop software which emphasises the cross-curricular transferability of problem solving skills. Consequently the subject matter of the programs varies from *TRAY* which draws on, highlights and strengthens the problem solving skills that the best modern theory sees as underlying the reading process to *BEES* which allows children to take control of scientific enquiry.

The programs are not to be seen as ends in themselves but the starting points for children to explore additional problems with the thinking tools they acquire.

They may also help alert teachers to the opportunities for investigational work and problem solving that can be found in the curriculum.

OTHER PROGRAMS

The value of *LOGO* to teaching problem solving is well known and there are a number of versions of it for both the BBC and Research Machines microcomputers. Teachers, in particular those of younger juniors and infants, will find programmable toys such as *BIGTRAK* (Milton Bradley Ltd) and *GEORGE THE COMPUTER ROBOT* (CGL) very useful as introductions to work with turtle graphics packages. Both are readily available in high street stores at around £30 and £20 respectively.

Apart from the programs in this pack there are several others, suitable for use with junior age children, which will prove most useful to teachers wishing to develop problem solving and investigational activities in their class:

1 Name: SMILE - THE FIRST 21
2 Source1: ILECC
3 Source2: 275 KENNINGTON LANE
4 Source3: LONDON SE11 5QZ
5 Info1: USEFUL PROGRAMS E.G. BOAT, NIM, RHINO,
6 Info2: CIRCLE, JUGS, SHOOTER,
7 Info3: QUEENS, ROSE, TILES
8 Micros: 380Z 480Z BBC
9 Cost: LEA LICENCES

1 Name: MINIBEE 5
2 Source1: ITMA
3 Source2: COLLEGE OF ST MARK & ST JOHN
4 Source3: DERIFORD ROAD PLYMOUTH DEVON
5 Info1: INCLUDES SEVEN AND SEVEN
6 Info2:
7 Info3:
8 Micros: 380Z 480Z BBC
9 Cost: £20

1 Name: GAMES OF DEDUCTION
2 Source1: FERNLEAF EDUCATIONAL SOFTWARE
3 Source2: 31 OLD WEST ROAD
4 Source3: GRAVESEND KENT DA11 ØLH
5 Info1: A SET OF FOUR PROGRAMS: PERFUME HUNTER,
6 Info2: FIND THE LADY, NAME THE SQUARE,
7 Info3: THE MESSAGE
8 Micros: BBC
9 Cost: £35.95

1 Name: GRANNY'S GARDEN
2 Source1: 4MATION EDUCATIONAL SOFTWARE
3 Source2: LINDEN LEA
4 Source3: ROCK PARK BARNSTAPLE EX32 9AD
5 Info1: AN ADVENTURE GAME FOR YOUNGER CHILDREN
6 Info2: WITH DOUBLE HEIGHT LETTERS AND COLOURFUL
7 Info3: GRAPHICS
8 Micros: BBC
9 Cost: CASS: £10 DISK: £12

1 Name: L
2 Source1: ASSOCIATION OF TEACHERS OF MATHEMATICS
3 Source2: QUEEN'S CHAMBERS
4 Source3: KING STREET DERBY
5 Info1: A "MATHEMAGICAL" ADVENTURE GAME
6 Info2:
7 Info3:
8 Micros: BBC
9 Cost: £9.95

1 Name: WATCHPERSON
2 Source1: MICROPRIMER PACK 3
3 Source2: TECMEDIA LTD
4 Source3: 5 GRANBY STREET LOUGHBOROUGH
5 Info1: FIND A ROUTE ROUND STREETS
6 Info2: WITHOUT RETRACING YOUR STEPS
7 Info3:
8 Micros: 480Z BBC SPECTRUM
9 Cost: PART OF DOI SCHEME

1 Name: FARMER
2 Source1: MICROPRIMER PACK 1
3 Source2: TECMEDIA LTD
4 Source3: 5 GRANBY STREET LOUGHBOROUGH
5 Info1: GET A FARMER, CHICKEN, DOG AND GRAIN
6 Info2: ACROSS A RIVER
7 Info3:
8 Micros: 480Z BBC SPECTRUM
9 Cost: PART OF DOI SCHEME

1 Name: EGGS
2 Source1: MEP PRIMARY MATHS PACK
3 Source2:
4 Source3:
5 Info1: USE TWO SAND TIMERS TO BOIL EGGS
6 Info2:
7 Info3:
8 Micros: 480Z BBC
9 Cost: FREE

BIBLIOGRAPHY

Texts marked with an asterisk are highly recommended.

* Jackson, K. F. (1975) *The Art of Solving Problems*. London: Heinemann

(This edition is no longer in print but a compact edition can be obtained direct from Professor Jackson at the following address: Bulmershe-Comino Problem-Solving Project, Bulmershe College of Higher Education, Woodlands Avenue, Earley, Reading, RG6 1HY.)

Grogono P. and Nelson S. (1982) *Problem Solving and Computer Programming*. London: Addison-Wesley
Although this text deals with the logic of computer languages and is quite advanced it is interesting to dip into. The Introduction, Chapters 1, 2 and 3 have useful sections on memory, insight, abstraction and isomorphic and similar problems.

Polya G. (1973) *How to Solve It*. Princeton University Press

Meyer C. and Sallee T. (1983) *Make It Simpler - A Practical Guide to Problem Solving in Mathematics*.

* Burton L. (1984) *Thinking Things Through*. Oxford: Basil Blackwell
Both the Meyer and Burton books contain examples of mathematical problems, investigations and puzzles which can be used in the primary classroom together with notes on their resolution.

Microprimer Study Text (1983). Loughborough: Tecmedia

Brown S and Walter M. (1983) *The Art of Problem Posing*. Philadelphia: The Franklin Institute Press
Chapters 3 and 4 explore what the authors call the 'what-if-not' strategy as a way of gaining new viewpoints on problems.

* Mason J., Burton L. and Kaye S. (1982) *Thinking Mathematically*. London: Addison-Wesley
A very readable book which shows approaches when the solver is seemingly 'stuck' on a problem.

D303 Block 4 Units 24-25 and 26-28 *Cognitive Psychology: Learning and Problem Solving*. (1978) The Open University Press

* Papert S. (1980) *Mindstorms: Children, Computers and Powerful Ideas*. Brighton: The Harvester Press Limited

If there is not enough time to read all of the book then it is worth looking at Chapter 3 which focusses on turtle geometry and contains many examples of children's work.

Thomas S. *No Problem* in The Times Educational Supplement (30.12.83)

Kent D. *Problem Solving - Doing What Comes Naturally* in The Times Educational Supplement (11.5.84)

Slesnick T. *Problem Solving: Some Thoughts and Activities* in Arithmetic Teacher (March 1984)

Lichtenberg D. *The Difference between Problems and Answers* in Arithmetic Teacher (March 1984)

Clemens S. R. *Systematic Experimentation - a Frequently Used Problem-solving Strategy* in Mathematics Teacher (March 1984)

Byrne N. *First Experiences in the Teaching of Getting Results and Solving Problems* in Problem-Solving News - The Newsletter of the Bulmershe-Comino Problem-Solving Project (Issue 12, July 1984)

The Bulmershe-Comino Problem-Solving Project.

BULMERSHE COLLEGE
EARLEY
READING
BERKSHIRE RG6 1HY

1. Introduction.

Human beings need to be able to get results and solve problems in order to survive and to live satisfying lives. Although the idea of getting results as a general theme in education is relatively uncommon, the idea of solving problems is discussed frequently and sometimes adopted as an educational objective. However, not much is done in schools to teach pupils either how to get results or how to solve problems in the general sense.

The Bulmershe-Comino Problem-Solving research project was set up in 1979 in order to help teachers and pupils to get better results in everything they do through the study and application of the principles of getting results and solving problems. The whole of the work of the project and its director is devoted to this purpose.

The project is at present funded almost entirely by the Comino Foundation. It is a collaborative venture with Bulmershe College of Higher Education, which provides accommodation and services and active support through the principal Dr H. Silver, the Head of Administrative Studies Dr A. Paisey and the Research Officer Mr. C. Adelma The College itself, as a result of the project, has become active in the application c the principles of getting-results and solving-problems in college management and teaching. Professor Jackson is the director and sole full-time member of the project.

2. What we mean by Getting Results and Solving Problems.

Problem-solving means many different things to many people. In the project this subject has five characteristics which may be used for comparison with other approaches or projects, as follows.

1. The subject is taught on a theoretical basis. There is a simple and coherent theory of what results and problems are and how they can be got or tackled, respectively.

2. The subject is general - it relates to everything - not just to certain school subjects, not just to education.

3. The subject is applicable immediately and directly. We do not have to wait until something special turns up. Results are wanted and problems need solving at all times and in all places.

4. The subject is methodical. There are clear-cut methods available for guiding our thoughts and actions in all the stages of result-getting and problem-solving where help may be needed.

5. The subject is personal. Unlike, say mathematics, the subject takes account of the feelings, emotions, values, objectives, skills, judgement, strengths and weaknesses of the person who has the problem.

More details of the approach we take to the subject are given in the appended paper entitled "The Essentials of Getting Results and Solving Problems".

PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
K. F. Jackson
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

3. The State of the Project.

The first year of the project was for giving courses on the principles of getting results and solving problems to 70 teachers in Berkshire and Hampshire, to be applied in teaching and in school management. The second year was for practical work in school. The third year was for collecting and interpreting the findings. During the life of the project several more courses for teachers have been run, adding another 100 teachers to the number who have had some training in this subject. In its fifth year, the project is now concerned with dissemination and promotion as well as continuing research and development in the application of the principles to the curriculum.

4. Findings.

Here are some of the findings that have emerged.

1. No-one in the profession is unaware of the constant flow of problems towards teachers and pupils.

2. Only a small minority of teachers do not think that there is a need for pupils to learn how to solve problems.

3. A considerable number of teachers want to do something to help pupils to solve problems.

4. Failures and disappointments in teaching this subject are extremely rare. There are many ways to teach it successfully.

5. Children aged 8 and upwards can learn the fundamental theory and principles of the subject, and brighter 10-year olds can absorb nearly all the important principles.

6. Infants can understand what it is to get results and solve problems and can tackle a wide range of problems under guidance of their teacher.

7. Through the study of result-getting and problem-solving pupils can gain in confidence and self-sufficiency and can be freed from a good deal of worry that problems cause. All this can unburden the teachers and free them to get on with the educational task.

8. Problem-solving is at present a relatively unexploited and undeveloped area of the curriculum that is available for enriching school work for the able. It is an area in which motivation comes readily and it is adjustable to the ability and interest of the individual pupil. It can reveal gifts that do not get noticed in other subjects.

9. Problem-solving and result-getting are applicable to the normal subjects of the curriculum such as maths, science, music, English, etc. There are particularly close relationships with the subjects of Design and Computer Studies. Problem-solving and result-getting provide a common base for linking together all of the subjects of the curriculum.

5. Teaching the subject of Getting Results and Solving Problems.

Here is some general advice based on our experience so far.

1. Start from experience. Do some practical activity in groups first and review it in general class discussion in order to start collecting some ideas on theory and methods from the pupils.

2. The teacher can complete the theory by introducing points left out by the class and then putting it into a systematic form.

3. In order to demonstrate how the theory and methods work it is usually unavoidable that they are first tried out by the pupils in application to artificial or imaginary situations. However, it is most important to provide practice in application to real problems that have occurred and which are currently being faced by the pupils, and this should be done as soon as possible, preferably before the same lesson is over.

4. The pupils need to be reminded of the principles regularly.

5. The teacher needs to give help in applying the necessary discipline to follow the system thoroughly.

6. In supplying the principles to the study of other subjects the secret of success is to use the basic principles first and use them directly, and not to try to invent some new twist tailor-made for the subject. Thus, in mathematics, for example, if the problem detected is that the pupil thinks a question is hard, do not offer a mathematical technique, but get him to define what his problem is. In other words, identify what he finds hard about the question, in order subsequently to help him to overcome or to get around the difficulty.

7. The pupils should be encouraged to challenge the principles of the system by testing them rigorously in action, and to build upon them if they come up with further theory and methods of their own.

8. If the teacher wishes the pupils to take more responsibility for the management of their own learning, they will be helped by being told about the control model of management as shown on the next page.

9. Lessons should be planned so as to include plenty of time for planning before activities begin and plenty of time afterwards for reviewing what happened.

6. The idea of a system for teaching to get educational results.

In all courses for teachers we try to put over the idea that teachers should regard themselves as being responsible for getting educational results through the operation of a teaching or learning system* Figure 1 shows how such a system should be related to their educational objectives and to the production of educational results, with feedback loops of information about the quantity and quality of results and about what is happening inside the system.

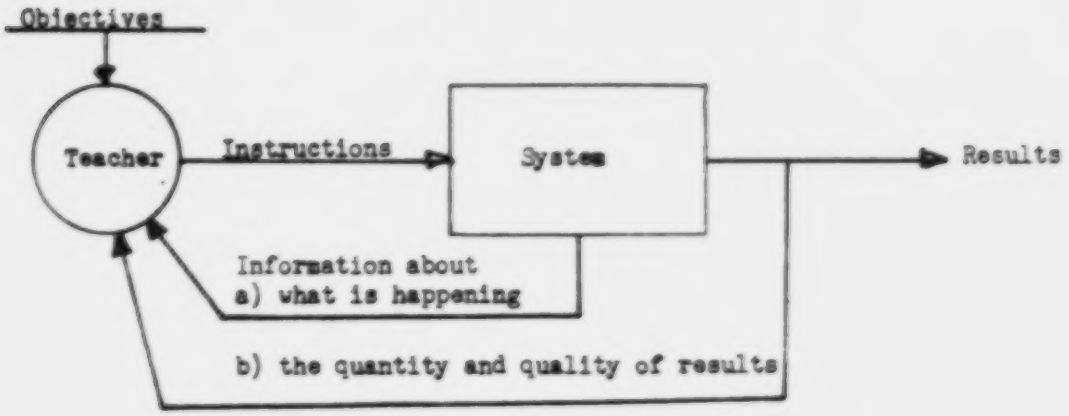


Figure 1.

Like any other management system, this one is composed of a set of resources which are organised with a view to achieving the desired objectives. In this case the objectives are educational ones. The teacher has his or her own resources of knowledge, skills and attitudes which can be used to produce learning. Another component of the system is the pupils themselves. They are the ones who have to do the learning - no one else can possibly do it for them. They need to be understood and managed so that they will perform at their best. Then there are various materials, such as books, pens and paper, apparatus and furniture. Space and time are also essential resources. All of these need to be organized into a coherent, effective and efficient system. Additionally, a general strategy, a variety of methods and a well prepared plan will be required to ensure that the system is capable of achieving its purpose.

* If the teachers can persuade the pupils to take over some of the responsibility themselves, so much the better.

The Coming Foundation is an educational charity whose efforts are directed to two principal purposes:-

1. To increase public awareness of the essential contribution to our society made by the wealth-producing sector of the economy.

2. To increase the effectiveness with which we use our brains to solve problems and ge results in our society generally but specifically in the fields of management and education.

Essentials of Getting Results and Solving Problems

1. There are better ways of getting results and solving problems which are methodical and systematic.

2. To get better results

	1. Get your objectives clear.
Planning and preparation	2. Develop a system for getting the results you want, by gathering and organising resources.
Action and control	3. Monitor the quantity and quality of results and the behaviour of the system. Compare with what ought to be happening and take corrective action.
Completion and review	4. As you get towards the finish, make sure that you complete the task properly and on time. Afterwards, review action and objective.

3. A task is what we have to do to get results.

4. A problem is a difficult situation that someone is trying to solve.

5. In every problem there is an objective and an obstacle.

6. To solve a problem we have to achieve the objective(s) and overcome the obstacle(s). The way to do it methodically is to go stage by stage.

7. Five stages of problem-solving are 1) Formulation, 2) Interpretation, 3) Constructing courses of action, 4) Decision-making, 5) Implementation.

8. Formulation contains:-

   1. Detection - we detect problems often through our feelings and emotions, or other people set problems for us. Detection means noticing that the problem is there.

   2. Identification - is classifying the problem or describing it.

   3. Definition - only methodical problem-solvers take the trouble to define problems in terms of objective and obstacle.

9. Interpretation of problems is necessary in order to produce understanding or comprehension. We enquire or investigate in order to interpret.
   If the material that we do not comprehend is complex, analysis will help.

10. Analysis can be done in four steps.
    1. List the elements.
    2. Consider them.
    3. Consider relations between them.
    4. Consider and evaluate the whole.

11. We need to record and show our comprehension by means of a description or model.

12. Constructing courses of action

    1. Set some general guiding principles, derived from objectives and results wanted, to which the solution should conform.

    2. Plan strategically - broad principles first, details later.

    3. Attend both to overcoming the obstacle and reaching the objective.

/cont.

13. Creative work

1. We need the right working conditions - such as some stimulation from others, and time-pressure.

2. We are all capable of creative work.

3. Vision is seeing states of affairs in the imagination which do not yet exist in reality.

4. Resourcefulness is seeing the value in that which we already possess.

5. Ingenuity is needed for finding courses of action or ways and means of getting from where we are now to where we want to go to.

14. Decision-making is for choosing what to do and for committing ourselves to action.

1. We ought to devise a system for making the decision if it is difficult or very important.

2. We need some qualities which are relevant. These can be derived from our objectives and system of values.

3. The qualities need to be assembled into a criterion for judging which course of action we prefer. If we want to select a definite number of courses of action, the criterion will involve putting the available alternatives in rank order. If an indefinite number, a standard to pass or fail will have to be set.

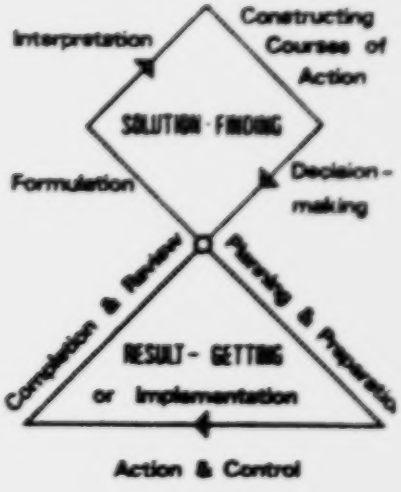
4. We need to measure or assess the qualities of the courses of action in terms which correspond to the nature of the qualities.

5. We need to apply the criterion and agree to carry out the preferred course of action which is identified by the criterion.

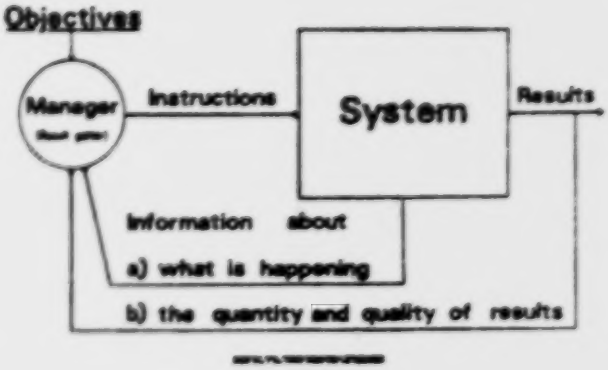
6. Decision-making sets a new objective which we now will pursue as a means to an end.

15. Implementation is the same as getting results.

The Problem-Solving Process



Getting Results by managing a System



Copyright © K.F. Jackson.

Reviewing an exercise or lesson

(1) What has happened?

(2) What did we do?

(3) What results did we achieve?

(4) What was the objective?

(5) Did the results meet the objective?

(6) Did we have a plan?

(7) Was it a good plan for that objective?

(8) Did we follow the plan?

(9) What methods did we use?

(10) What were the effects of the methods we used?

(11) Should these methods be kept, improved, or thrown out?

(12) Was it a good objective?

(13) What have we learnt?

(14) How could we do better next time?

Copyright © K.F.Jackson

STAGES AND PROCESSES OF PROBLEM SOLVING

STAGES:	PROCESSES:
Throughout	**BE SYSTEMATIC** A systematic strategy applied to solving problems will usually prove more successful than a haphazard approach. **TALK THROUGH THE PROBLEM IN YOUR HEAD** Thinking about a problem, asking questions about it and making explicit what is known and what is to be found are techniques that often serve to clarify a previously obscure problem. **COLLABORATE WITH OTHERS** Members of groups can often spark ideas off one another and so make progress towards a solution. *Examples:* TRAY: The discussion of the uncompleted text may reveal interpretations and insights that have not previously been considered. **COMMUNICATE THOUGHTS TO OTHERS** This is a useful technique for clarifying and ordering ideas and would be an essential component of solving the problems presented in each program.

2(a) and 2(b)

CONSIDER ALL THE INFORMATION GIVEN

The solution to a problem will invariably depend upon the solver considering all the information given in the problem, whether stated or implied.

Examples:

RAYBOX: When a number of rays have been fired it should be possible to conjecture the locations of most, if not all of the atoms.

TRAY: By looking at those letters, words and phrases which have already been revealed it may be possible to gain some insight into the composition of the whole passage.

2(a), 2(b) and 3

SEARCH FOR RELATIONSHIPS
The identification of links between seemingly discrete data can make sense of a problem and provide an insight into a possible method of solution.
Examples:
BEES: It is necessary to look for links between the stages of the dance and the position and quantity of the sources of nectar.
CHICKS: The pecking behaviour must be interpreted in the light of the properties of the blocks.

TRY PARTICULAR CASES
Seeing "what happens if" is usually necessary in order to get a sense of a problem and begin to make progress towards its solution. Typical is when values are substituted for letters in algebraic formulae.
Examples:
SPIRO+: Various combinations of wheels and rings must be tried if the underlying mathematical ratios are to be revealed.
TRIANGLES: If one is to understand the relationship between the screen locations of the triangles and the coordinates then sample values must be tried.

LOOK FOR SIMILAR PROBLEMS
Finding the solution to a problem will be facilitated if a problem, similar to that under consideration, can be solved.
Examples:
SHUNT: A file of procedures can be built up which can be drawn upon in order to solve stages of the shunting.
SECRET: The method used to encipher a particular message may be similar to that successfully deciphered on a previous occasion.

LOOK FOR SIMPLER PROBLEMS
An insight into a way of attacking an involved problem can often be gained by

finding a simpler problem for which a solution can be found.

Examples:

SPIRO+: Complex patterns can be drawn by adapting and combining those combinations of wheels and rings used to construct simpler designs.

COLONY: It will be easier to develop a winning strategy if moves on the 3x3 grid are analysed before using the 5x5 grid.

CONTROL VARIABLES

Where an outcome is dependent on the interplay of several variables then it is necessary to isolate one at a time so as to assess its particular effect.

Examples:

BEES: It is easier to analyse the dance by repositioning groups of flowers of the same size at varying distances from the hive.

CHICKS: Changing the colours of blocks whilst retaining, say, a common cuboid shape will highlight preferences in the chicks' pecking behaviour.

DEVELOP A WAY OF MODELLING THE PROBLEM

The use of diagrams, pictures or apparatus to make a representation of the problem can make it easier to apprehend.

Examples:

SPIRO+: Simple formulae can be used to calculate the number of revolutions and nodes produced by any combination of wheel and ring.

SHUNT: Toys, diagrams and even linked centicubes can serve as represention of the screen trucks and engines.

USE IMAGERY

Children generally find it helpful to develop their own imagery and terminology to help them conceptualize a problem.

Examples:

RAYBOX: Children have used the idea of atoms possessing a 'force-field' to aid their understanding of rays being deflected

COLONY: The image of seed pods bursting may help the children to grasp the idea of explosions.

ATTACK SUBPROBLEMS

It is helpful to break an intricate problem down into manageble chunks and attack each separately.

Examples:

SHUNT: A procedure for shunting one truck may be devised then used as part of a larger procedure to move all the trucks.

SPIRO+: Complex designs can be constructed by drawing and combining simple components.

USE FAILURE POSITIVELY TO ELIMINATE PATHS

If particular avenues of investigation fail to lead to a solution then they can be eliminated from consideration so narrowing the field.

Examples:

BEES: Hypotheses about the various elements of the dance can be discounted by trial and error.

RAYBOX: After several rays have been fired it should be possible to cross out positions where atoms cannot possibly lie.

USE TRIAL AND ERROR

Mistakes are unavoidable when attempting to resolve problems. However they should not discourage the solver as they provide valuable information which can be the basis for further trials.

Examples:

SUPER RAY:

Rays will need to be fired in order to begin to gain some idea of the rules governing their effect on the atoms.

TRAY:

At first there will be so few letters revealed that words and phrases will need to be guessed.

DEVELOP A MEANS OF RECORDING RESULTS

This is necessary in order to be able to chart progress and identify possible routes to a solution.

Examples:

WALLPAPER: Draw the positions of motifs on

a grid.
BEES: Use a grid to show how the variations in the dance are associated with the locations of the flowers.

LOOK FOR PATTERNS
Underlying patterns have to be identified if a generalization is to be made.
Examples:
SPIRO+: Different combinations of wheels and rings will produce identical designs. By examining the ratios of the number of teeth on the wheels and rings of each of these combinations underlying mathematical relationships will emerge.
CHICKS: The pecking behaviour of the chicks towards various classes of objects will show patterns.

DRAW OUT A PARTICULAR RULE
It may be possible to state a rule which governs all instances of a problem.
Examples:
BEES: After setting up controlled conditions to study changes in the bees' dance it will be possible to make a general statement about the relation of each facet of the dance to the location and size of patches of flowers.
STRATEGY: General rules can be stated about the best moves depending on which player has the first turn.

4

DEVELOP AND TEST HYPOTHESES

The reasoning underlying a possible solution to a problem should be given then the hypothesis tested to see if it holds under all conditions.

Examples:

SUPER RAY: By experimenting with the positioning of the atoms it will be possible to try to disprove a hypothesis about the rules governing the behaviour of the rays.

SPIRO+: Predictions can be made about about the number of revolutions and nodes created by different combinations of wheels. These can be tested by keying in the relevant values for the number of teeth on each.

TRY EXTREME CASES

One way of testing a hypothesis is to try extreme cases. This will help to highlight underlying patterns of results and it may show that the hypothesis does not hold after all.

Examples:

BEES: Try placing large patches of flowers as close as possible to and as far away from the hive in order to see the contrast between the resulting dances.

SUPER RAY: Arranging a large number of atoms in the box in a particularly contrived pattern may help to prove/disprove whether the behaviour of the rays follows the expected course.

6

EVALUATE HOW YOU SOLVED THE PROBLEM AND CONSIDER WHETHER THERE WERE BETTER WAYS

The review stage should not be neglected as it offers the opportunity to reflect on the methods used to solve the problem and consider whether a more efficient strategy could have been employed.

Examples:

RAYBOX: Could fewer rays have been fired in order to discover the locations of the atoms?

SECRET: Would tests for common double letters or blends have helped to decipher the message sooner?

First experiences in the teaching of Getting Results and Solving Problems.

by Nora Byrne.

I work at Stansfield Road Junior School in Oldham and I teach a Junior I class of twenty-four children.

In the Spring term I undertook a ten-week course on Getting Results and Solving Problems run by the Oldham Education Department Curriculum Workshop.

Effects

The effects of the course upon me have been threefold. Firstly, on a personal level, I enthusiastically set about applying the five-stage problem-solving approach to any situation about which I had unsettled feelings. The results were highly satisfactory. More importantly, it was an easy and interesting way to internalize the problem-solving strategy.

Secondly, as a professional skill, the course has made me more aware of the need for clearly-stated objectives and more effective as a teacher by applying result-getting and problem-solving methods to the learning situation.

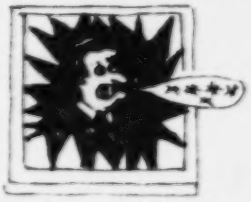
Thirdly, I enjoyed the challenge posed by endeavouring to teach this subject to Junior I children.

My approach

The following is a broad outline of the approach that I have taken. As a teaching project it falls loosley into eight parts. The first part of the project was concerned with teaching the children an understanding of what a problem is. This involved introducing both the symbol of and vocabulary for a problem (Problem = objective + obstacle). It also involved considerations about how we detect problems, where they come from and how the same central situation may or may not be a problem, depending upon circumstances.

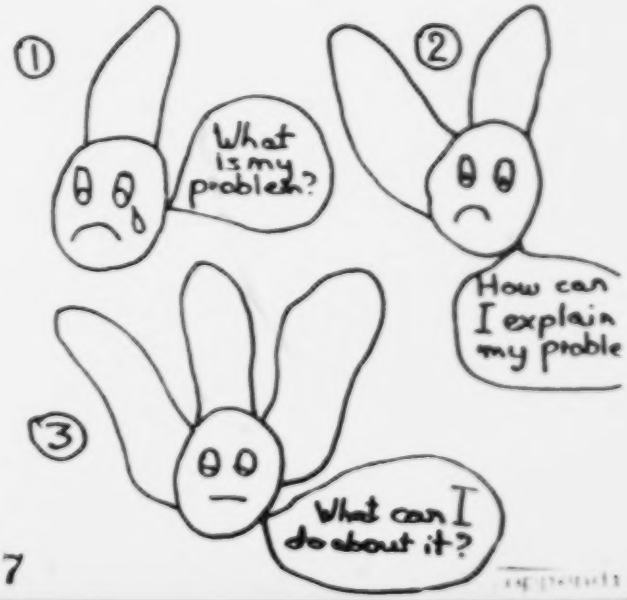
The children were presented with several pictures which depicted situations with a problem element. For example, Picture (1) Sweets on a high shelf. Picture (2) A boy swimming in the sea. He can see a shark in the distance. Picture (3) A mother is talking to another lady. Her little boy wants to go home. Through discussion of the pictures the children came to an understanding of what an obstacle is and what an objective is. The children went on to give many examples of their own problems and with practice applied the P = O+O rule with increasing accuracy.

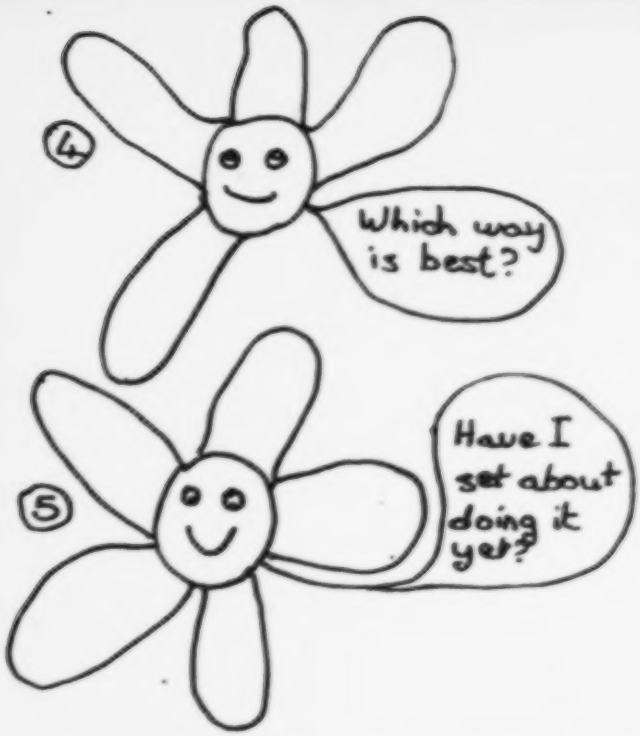
The second part of the teaching programme was concerned with the presentation of the five-part problem-solving strategy (Formulation, Interpretation, Constructing Courses of Action, Decision Making, Implementation). Since on a personal level I had found this strategy easiest to internalize in the context of a specific problem-situation, I decided to present it in such a way I also chose to introduce the vocabulary of problem-solving as used by adults to the children directly. I have often found that in the context of a meaningful experience children do not have great difficulty in aquiring new or seemingly difficult vocabulary.



Starfish

To do this I wrote a story about a starfish with a problem. He looks like a blob of jelly, and he wishes to be handsome and have five starfish points, like his brother Harry. A kind wizard helps him with his problem. In order to grow his five starfish points he needs to ask and answer five special questions. The questions lead him through the stages of the problem-solving strategy.





At the end of the story the wizard gives the starfish a reminder-chart so that he will know exactly what to do about any future problems. The children made their own copies of the chart. (See chart (A)). They now use their charts when they are attempting to solve a problem. They write their own responses to the five questions on a blank problem-sheet. (See Chart B).

Of the twenty-four seven-to-eight-year olds in the class, nine children were able to use the strategy independently, straight away, with the aid of the reminder chart only.

In the next five parts of the teaching programme, these nine children, working as a group, set about examining each part of the strategy in greater depth.

Part 3: **Formulation:** The children asked themselves how they first noticed that a problem was beginning to grow. Did they feel angry, sad, confused, afraid, miserable? They tried to decide what sort of a problem it was. To make this classification easier the children compared their individual problem to one of the six types of problem illustrated on their problem-cube. (See chart (C)). Then they attempted to formulate their problem clearly and briefly stating the objective and the obstacle.

Part 4: **Interpretation:** Without using some analysis at the interpretation stage the work often became a restatement of the formulation, without producing any further insights. However, once the children were encouraged to go through the steps of analysis the results obtained were much more helpful. The words we chose to state the steps in analysis were:-

1. Make a list of all the clues or objects.
2. Think about each clue or object in turn.
3. Think about the way the clues or objects link up with one another.
4. Put the clues or objects back together so that they make a picture, or tell a story, or we understand it better.

In order to get some practice in analysis, before applying it at the interpretation stage of a problem, we did some exercises. Some examples were as follows. (a) Analyse a group of about 100 Christmas-cracker-type toys of assorted colours. They included dogs, boats, cars of different types, lambs, elephants, horses with or without riders, piglets, fairytale characters.

The children sorted the toys into various groups. They considered each group in turn and speculated at great length about the characteristics and properties of each. They considered how the clues or objects linked up with one another. For example - Sport:- racing cars, speed boats, racehorses, show dogs. Farm Animals:- pigs, horses, lambs, dogs. Things that are animals. Things that are machines. Things from different countries. Things to ride in or on. One boy made a chart to show the relationships between the toys.

In another instance two children set about arranging ½lb of liquorish allsorts according to the rules of analysis.

The children were then encouraged to relate the analysis process to the interpretation stage of problem-solving.

Part 5: **Constructing Courses of Action:-** The children were encouraged to think of courses of action which were unusual as well as usual. As their confidence grew they produced more responses to a given situation.

(cont'd on page 4)

Part 6: **Decision-Making:-** When making their decisions, the children were encouraged to consider firstly their original objective and secondly the things of importance to them and then to make their choice in the light of those two sets of considerations.

Part 7: **Implementation:-** The children were encouraged to:-

- plan their actions.
- get together all the things they needed to use.
- make sure they completed their task.
- discuss the outcome of their actions in order to determine why they were either successful or unsuccessful.

The eighth part of this teaching programme is the stage I am presently at.

I now have a group of children within the class who, with the help of various charts and aids for guidance, can work with relative independence.

Problem-box

To improve general competence in the area of problem-solving we have made a collection of problems in a problem-box. The children have written and illustrated a large proportion of these problems.

Introducing the subject of Getting Results and Solving Problems has been an enriching experience for everyone involve It has been enjoyed on many levels. For example, some children not in the main gr have become very involved with specific aspects of the work. A small group of bo spent a long time discussing and analysin a large collection of containers. Anothe group of less able pupils enjoyed produci some drawings with a P = 0+0 element for other children to consider.

Perhaps the most striking benefit fr the course is the facility that the childr are developing to exercise control over a problem situation. Working within the framework of the five-part strategy, their discussion is more purposeful, their questions more directed, and they unearth previously hidden implications, or further difficulties, much sooner.

As the work proceeds in the Summer term, I wish to teach the essentials of Getting Results ((1) Clear objectives (2) Planning and gathering resources (3) Actio and control (4) Completion and revie), in relation to the topic-related craft work. Our topic for the Summer is, 'Under the Ground'.

N.B.

CHART (A)

Formulation	What is my problem ?	1. Notice it is there. 2. Decide what sort of problem it is. What is the objective? what is the obstacle? 3. Say in own words what your problem is.
Interpretation	How can I explain my problem ?	Bring together ideas about the problem. What things do we notice? Can we read about it ? Can we ask questions? Can we ask advice?
construct courses of Action	what can I do about it ?	Think about all the different ways you might be able to solve your problem.
Decision Making	Which way is best ?	Choose the best way to solve your problem. How can you do it?
Implementation	Have I set about doing it yet ?	1. How am I trying to do it ? 2. Have I finished ? 3. Have I been successful ?

Problem Sheet

CHART (B)

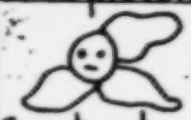
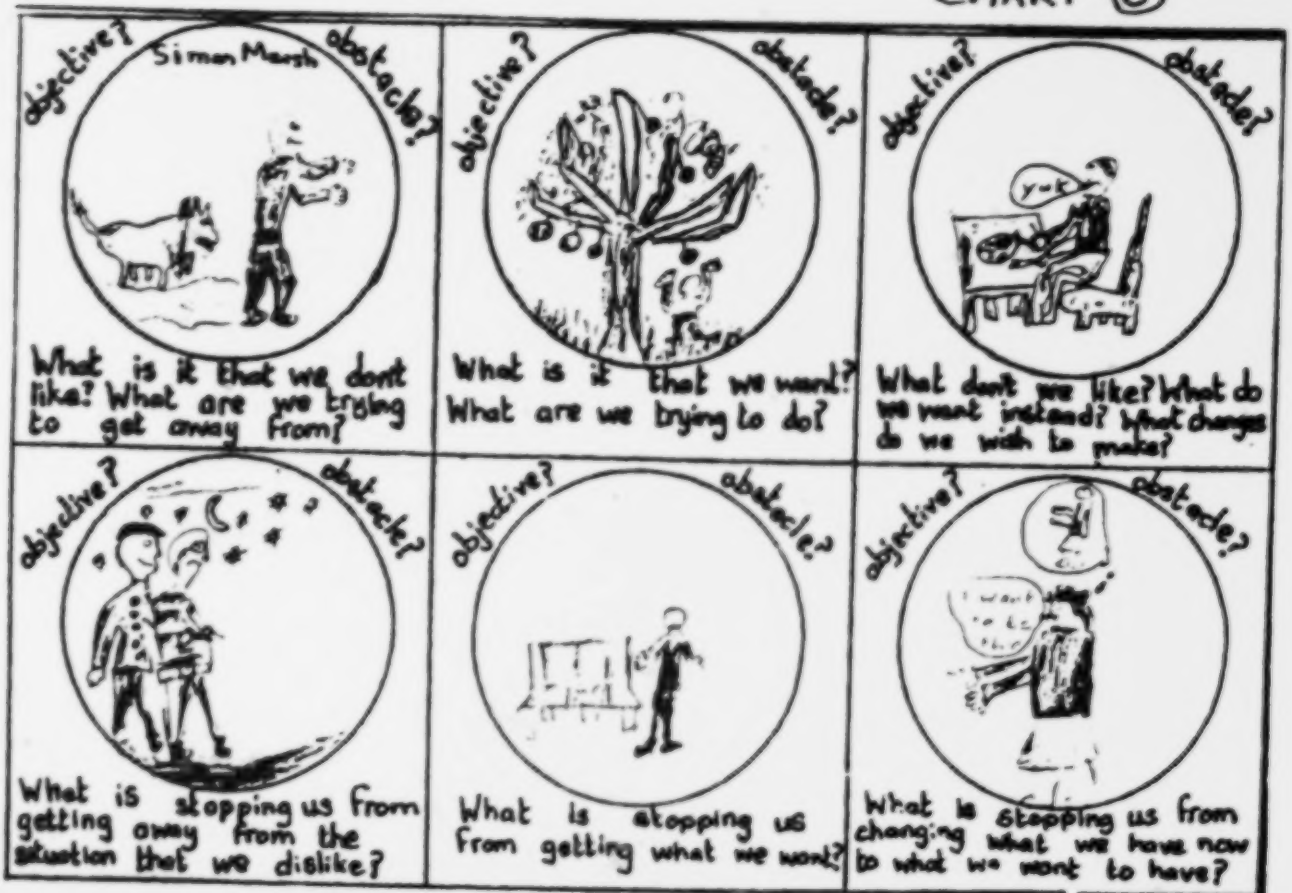
Formulation	What is my problem?	
Interpretation	How can I explain my problem?	
 Construct courses of action	What can I do about it?	
Decision Making	Which way is best?	
Implementation	Have I set about doing it yet?	

CHART (C)


objective?
obstacle?
Simon Marsh
What is it that we don't like? What are we trying to get away from?
objective?
obstacle?
What is it that we want? What are we trying to do?
objective?
obstacle?
What don't we like? What do we want instead? What changes do we wish to make?
objective?
obstacle?
What is stopping us from getting away from the situation that we dislike?
objective?
obstacle?
What is stopping us from getting what we want?
objective?
obstacle?
What is stopping us from changing what we have now to what we want to have?

ISSN 0260-5554

PROBLEM-SOLVING NEWS

ISSUE NO. 12. JULY 1984

The Newsletter of the Bulmershe-Comino Problem-Solving Research Project

EDITORIAL

Leadership

A new turn of events has directed attention in the Bulmershe-Comino Problem-Solving project towards the study of leadership. In recent years a small number of people have reported considerable success in applying the principles of getting results and solving problems by themselves or with the co-oporation of team-mates when they were taking part as students in training courses on leadership. Now we have had some first-hand experience of running a course for Army trainers. The participants were instructed to find out what makes for success in leadership through the experience of tackling a wide variety of tasks under their own leaders using the principles of getting results and solving problems and using a systematic process for reviewing their work after each exercise. A humorous and detailed description of this experience by the journalist Susan Thomas was published in the Grassroots series in The Guardian on 7th July 1984. We hope that as a result of this publicity the project will have further opportunities to collaborate with the Services and other organizations concerned with leadership.

Science

When the Bulmershe-Comino Problem-Solving project began, nearly five years ago, the educational issues most frequently mentioned by enquirers were C.D.T. and giftedness. At present the issue enquired about most frequently is science. One reason for this is the existence of a strong movement in science education which seeks to promote the use of "the problem" as a vehicle for learning. "The problem" in this sense is a project or exercise which is set and given to the pupils to tackle. Since in the project we prefer to confine the use of the term "problem" to difficult situations where there are obstacles to progress, it becomes necessary to explain the difference in meaning between these two usages when discussing the application of the principles of getting results and solving problems to education in science. Apart from this divergence of usage it appears that the teachers of science find that they can appreciate the value of the principles and envisage ways and means of applying them at various levels in the curriculum.

Doubts

The subject of problem-solving has attracted so much attention that some people have become uneasy about it and have written journal articles to express their anxieties. Most of the difficulties seem to arise from the vague and ambiguous ways in which terms like "problem" and "skills" are used. It is unfortunate that this is so, but at least it gives an indication of the strength of the growing interest in our subject. Readers are invited to help in clarifying these matters by drawing the attention of Problem-Solving News to published items of this type.

Competition - Here's a Problem!

When I take documents out of their files to use in a meeting or a talk, a) I am prone to lose track of them, and b) it uses up valuable time to put them away again afterwards. How can I avoid these disadvantages? Readers, please send in your suggestions to Problem-Solving News. This is a competition, and the prize of a copy of 'The Art of Solving Problems' will be awarded to the sender of the best entry received before 1st October.

Published at Bulmershe College of Higher Education, Woodlands Avenue, Earley, Reading, Berks. RG6 1HY. U.K.

Editorial Board: Professor K.F. Jackson, Dr A. Paisey, Jane Ballard and John Thorogood.